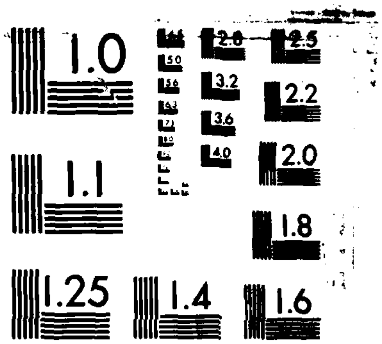
AD-A167 366 A MODEL OF US ARMY MATERIEL COMMAND (AMC) ENERGY CONSUMPTION VOLUME 1 DEV..(U) CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL B J SLIWINSKI MAR 86 1/1

UNCLASSIFIED CERL-TR-E-86/02-VOL-1 F/G 13/1 NL



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

US Army Corps
of Engineers
Construction Engineering
Research Laboratory

USA-CERL

TECHNICAL REPORT E-86/02
March 1986
DARCOM Energy System Modernization

A Model of U.S. Army Materiel Command (AMC) Energy Consumption, Volume I: Development of Monthly Energy Consumption Equations

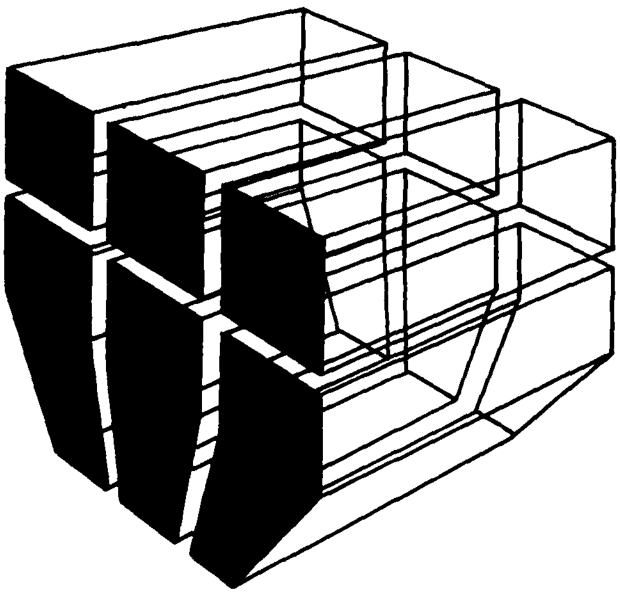
by
Ben J. Sliwinski

This report describes the development of equations to relate monthly energy consumption at U.S. Army Materiel Command (AMC) installations to weather and process parameters. Equations were developed using multiple linear regression analysis for the Armament Munitions and Chemical Command (AMCCOM) and Depot Systems Command (DESCOM) major subcommands of AMC.

Multiple regression analysis is the process of fitting a curve to a set of data points. This technique, commonly known as least squares curve fitting, is based on minimizing the sum of the squares of the errors between the data and the fitted equation. Once the regression analysis is performed, it is possible to generate confidence limits about the fitted equation. For example, the 95 percent confidence limits determine the range of data values that will fall within the limits 95 percent of the time. The confidence limits are useful in making statistically valid statements about the meaning of future observations.

The accuracy of both the individual and the command-level equations is described, and examples for calculating confidence limits of the equations are given. Results in using the equations to predict AMCCOM and DESCOM total energy consumption indicate they provide a useful tool for managing AMC energy use. Lumped data regression was used to analyze energy consumption data for AMCCOM, and efforts are now under way to apply it to DESCOM data.

Volume II of this report provides installation equations and related statistics.



REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER CERL TR E-86/02	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) A MODEL OF U.S. ARMY MATERIEL COMMAND (AMC) ENERGY CONSUMPTION, VOLUME I: DEVELOPMENT OF MONTHLY ENERGY CONSUMPTION EQUATIONS	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Ben J. Sliwinski	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Construction Engr Research Laboratory P.O. Box 4005 Champaign, IL 61820-1305	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 4A162781AT45-B-12
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE March 1986
	13. NUMBER OF PAGES 33
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are available from the National Technical Information Service
Springfield, VA 22161

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Army Materiel Command
energy consumption
Regression Analysis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the development of equations to relate monthly energy consumption at U.S. Army Materiel Command (AMC) installations to weather and process parameters. Equations were developed using multiple linear regression analysis for the Armament Munitions and Chemical Command (AMCCOM) and Depot Systems Command (DESCOM) major subcommands of AMC.

Multiple regression analysis is the process of fitting a curve to a set of data points. This technique, commonly known as least squares curve fitting, is based on

BLOCK 20 (Cont'd)

minimizing the sum of the squares of the errors between the data and the fitted equation. Once the regression analysis is performed, it is possible to generate confidence limits about the fitted equation. For example, the 95 percent confidence limits determine the range of data values that will fall within the limits 95 percent of the time. The co fidence limits are useful in making statistically valid statements about the meaning of future observations.

The accuracy of both the individual and the command-level equations is described, and examples for calculating confidence limits of the equations are given. Results in using the equations to predict AMCCOM and DESCOM total energy consumption indicate they provide a useful tool for managing AMC energy use. Lumped data regression was used to analyze energy consumption data for AMCCOM, and efforts are now under way to apply it to DESCOM data.

Volume II of this report provides installation equations and related statistics.

FOREWORD

This work was performed for the Office of the Assistant Chief of Engineers (OACE) under Project 4A162781AT45, "Energy and Conservation"; Task B, "Installation Energy Conservation"; Work Unit 12, "DARCOM Energy System Modernization." The work was performed by the Energy Systems Division (ES) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). Mr. B. Wasserman (DAEN-ZCF-U) was the OACE Technical Monitor. Mr. R. G. Donaghy is Chief of USA-CERL-ES.

Appreciation is expressed to Dr. M. Binder of USA-CERL for his assistance in the statistical analysis.

COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

A-1

CONTENTS

TABLES

FIGURES

A MODEL OF U.S. ARMY MATERIEL COMMAND (AMC) ENERGY CONSUMPTION, VOLUME I: DEVELOPMENT OF MONTHLY ENERGY CONSUMPTION EQUATIONS

1 INTRODUCTION

Background

Between 1975 and 1981, the U.S. Army Materiel Command (AMC) experienced a 26 percent reduction in energy consumption. At the same time, there was a significant reduction in production levels of military materiel systems. To correlate the effects of production levels and other mission parameters with energy consumption, the AMC energy office asked the U.S. Army Construction Engineering Research Laboratory (USA-CERL) to develop a method of analyzing AMC energy consumption. This information was to be used to formulate and carry out energy conservation policies.

The first effort in this analysis was a process energy inventory at Watervliet Arsenal.[1] A second effort made a preliminary estimate of what percentage of AMC energy is currently used in the manufacturing process.[2] However, to allow AMC to set sound goals, measure compliance with these goals, and improve management of their energy conservation activities, a method was needed that would allow impacts of the many parameters affecting AMC energy consumption to be evaluated.

Objective

The objective of this report is to develop a method of evaluating the impact of parameters affecting AMC energy consumption. Volume I describes the development of regression equations and Volume II contains the detailed data.

Approach

Data related to energy consumption were gathered for various installations of AMC's two major subcommands: the Armament Munitions and Chemical Command (AMCCOM) and the Depot Systems Command (DESCOM). Regression analyses were then performed to produce equations for the major command level and the installation level. An application of the equations was provided to illustrate their use.

Lumped data regression was used to estimate FY84 energy consumption for AMCCOM. Efforts to apply lumped data regression to DESCOM data are now being made.

---

[1] M. Chionis and B. Sliwinski, *Process Energy Inventory at Watervliet Army Arsenal*, Technical Report E-199 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], 1984).

[2] B. Sliwinski, *An Estimate of Process Energy Consumption in DARCOM*, Technical Report E-189/ADA135418 (USA-CERL, 1983).

Mode of Technology Transfer

The results of this study are being transferred by briefings given to the AMC Energy Office and through computer software which will be used by AMC, AMCCOM, and DESCOM Headquarters.

2 METHODOLOGY

Several methods of analyzing AMC energy consumption were considered. The first method involved metering of the individual process and nonprocess energy consumers within each AMC installation. It became apparent from the Watervliet study that although this method potentially could be very accurate, application to all the AMC facilities would be very expensive.

The second method examined use of aggregate data reported to the Commerce Department by Standard Industrial Code (SIC). This method has the advantage of low cost, but the coarseness of the data produces unacceptably low accuracy for purposes of this study.

The third method examined was the use of multiple linear regression analysis for each AMC facility using historical energy consumption and process parameter data from each facility. It was determined that this method provided the best trade-off between cost, accuracy, and potential usefulness.

Data Gathering

The first step in developing the regression equations was acquiring data on all parameters affecting energy consumption for each AMCCOM and DESCOM installation to be analyzed. Most of the data were obtained from the U.S. Army Logistics Support Service Activity (LSSA), AMCCOM headquarters at Rock Island Arsenal, the National Oceanic and Atmospheric Administration (NOAA), and the DESCOM headquarters at Letterkenny Army Depot. In some cases, supplementary data were gathered from the installations.

Three types of data were gathered: (1) Defense Energy Information System (DEIS) energy consumption data for AMCCOM (1975 through 1982) and for DESCOM (1975 through 1983), (2) weather data for each facility, and (3) data on process parameters. The process parameter data differed for each installation. Table 1 lists the data gathered, including typical process parameters. Tables 2 and 3 list the NOAA weather stations which provided data for each AMCCOM and DESCOM installation, respectively.

Regression Analysis

The regression analyses of the data followed the same basic format for all installations. In each case, a linear model of the following form was assumed:

$$\text{Energy} = \text{Constant} + \text{Weather Parameter(s)} + \text{Process Parameter(s)}$$

Statistical analyses were performed using the Statistical Analysis System (SAS) software package. Stepwise regressions were performed for each dependent variable on appropriate sets of independent variables. In stepwise regression, independent variables are entered, one at a time, according to some predetermined criterion. The criterion used in this study was the maximum improvement in the R^2 value.*

*R^2(Multiple Coefficient of Determination): Sum of Squares due to regression/total sum of squares, corrected for the mean. R^2 measures the proportion of total variation about the mean $\bar{y}$ that is explained by the regression.

3 MAJOR COMMAND LEVEL EQUATIONS

The regression analyses produced several equations for each AMC installation, an overall equation for total energy consumption, and one equation for each major type of energy consumed (electricity, coal, oil, natural gas).

In assembling a set of equations to be used at the major command level, only the overall installation energy consumption equations were considered. Since the overall equation is developed in steps during each regression, there are several possible overall equations to choose from for each installation--one for each step.

In general, equations were of the form MBTU = B0 + B1 + HDD + B2 * OTHER. For example, for each installation, the regression process would develop an overall equation in the following manner:

Step 1 equation	$Energy = B0_1 + B1_1*HDD$	$R^2 = 0.75$
Step 2 equation	$Energy = B0_2 + B1_2*HDD + B2_2*LBRFRC$	$R^2 = 0.85$
Step 3 equation	$Energy = B0_3 + B1_3*HDD + B2_3*LBRFRC$ $+ B3_3*ITEMS$	$R^2 = 0.91$

This process might continue until there were many independent variables in the equation, resulting in a very high R^2. However, in developing equations for use at the major command level, the amount of information that must be gathered to use the equation was an important consideration. Therefore, to reduce input data gathering, the set of major command level equations was chosen by picking equations from each installation that had a minimum number of independent variables, but would still maintain an R^2 of 0.80 or better. Tables 4 and 5 give the AMCCOM and DESCOM command level equations and data for 95 percent confidence limit calculations.

Influence of Labor Force in AMCCOM

The AMCCOM equations indicate the dependence of AMCCOM energy consumption on heating degree days (HDD) and labor force strength (LBRFRC). In particular, changes from year to year in AMCCOM energy depend on LBRFRC. This is illustrated by comparing a plot of the historic trend in the AMCCOM labor force with energy consumption for the same period (Figure 1).

Typical Results From AMCCOM Equations

The set of AMCCOM equations generates results that closely follow the historical trend in AMCCOM energy consumption. The set of equations is also an accurate predictor of future AMCCOM energy consumption. Figure 2 illustrates the results of using the equations to predict FY84 energy consumption. The independent variables were actual HDD and LBRFRC, so that in a sense, the results are more of a verification than a prediction (i.e., inaccuracies in estimating weather data and labor force are not introduced).

Lumped Data Analysis for AMCCOM

As shown in Table 4, AMCCOM installations form two distinct groups. The first group (HDD installations) consists of installations whose overall energy consumption depends on HDD only (i.e., B2 = 0), whereas the second group (HDD/LBRFRC installations) consists of installations whose overall energy consumption depends on both HDD and LBRFRC. For each of the 96 months in the original database (FY75-FY82), the appropriate parameters (either HDD or HDD and LBRFRC) and MBTU were summed over the installations in each group. Regression analysis was then applied to the resulting two groups of 96 data points. The first 12 data points were then eliminated from both groups and regression analysis applied to the remaining two groups of 84 data points (FY76-FY82). This procedure was repeated until the final regression consisted of only 12 points for each group (FY82). The result was eight regression equations for each of the two groups. Table 6 summarizes the results, along with the resulting value of R^2 for each equation. An overall equation for all AMCCOM installations for any given fiscal year range can be obtained by summing the appropriate equations for each group.

This was done for each fiscal year range, and the resulting eight equations used to predict total AMCCOM energy consumption on a quarterly basis for FY84. Table 7 gives the results. Of particular interest are the equations representing FY range 76-82 and FY range 77-82. On a quarterly basis, these two equations become:

FY range 76-82:

$$\mathrm{MBTU} = 1113514.6 + 54.3 * (\mathrm{HDD})_1 + 49.2 * (\mathrm{HDD})_2 + 86.2 * (\mathrm{LBRFRC})_2$$

FY range 77-82:

$$\mathrm{MBTU} = 1659515.3 + 53.1 * (\mathrm{HDD})_1 + 45.3 * (\mathrm{HDD})_2 + 64.5 * (\mathrm{LBRFRC})_2$$

where:

$(\mathrm{HDD})_1$ = total HDD for the quarter summed over all HDD installations

$(\mathrm{HDD})_2$ = total HDD for the quarter summed over all HDD/LBRFRC installations

$(\mathrm{LBRFRC})_2$ = total LBRFRC for the quarter summed over all HDD/LBRFRC installations.

Figure 3 presents total AMCCOM energy consumption predictions for FY84 as given by the lumped data (LD) equation for FY range 76-82 (LD 76-82) and as given by a summation over all the individual installation equations (IE). The single equation (LD 76-82) essentially duplicates the results given by the summation over the 23 individual installation equations. Figure 4 presents actual AMCCOM energy consumption for FY84 and predicted energy consumption from both the installation equations and the LD equation for fiscal year range 77-82 (LD 77-82). The LD equation gives slightly improved accuracy for the second quarter, and highly improved accuracy for the fourth quarter. Figure 5 plots LD 76-82 and LD 77-82 equations against actual energy use for FY84. The actual energy consumption is well bounded by the two LD equation predictions. In general, accuracy of regression equations is improved as the number of data points increases, provided that significant changes in operational trends do not occur in the regression database. Table 8 gives predicted and actual values of MBTU for

individual AMCCOM installations. The Actual/Predicted Column indicates that although most of the installation equations are predicting annual energy consumption very accurately, several are highly inaccurate. Most notable is the Volunteer Army Ammunition Plant (AAP). As shown in Figure 6, the production level decreased considerably in the early years of the original database. That is, FY75-FY82 is not a valid database for predicting current energy consumption at that installation. Hence, LD 77-82 may be expected to be more accurate than LD 76-82 for quarters in which total energy consumption is dominated by production-related terms (i.e., fourth quarter), because the former data range is more typical of current production levels at Volunteer AAP. If future actual energy consumption data continue to be bounded by LD 76-82 and LD 77-82 as in Figure 5, it may be possible to use both equations with appropriate weighting factors related to the fiscal quarters for improved accuracy energy predictions.

Major command level energy consumption may be predicted by either the individual installation equations or the LD equations. The former method requires calculating predicted MBTU from 23 different equations, with subsequent summation of the calculated values over the time period of interest and the application of a single equation. Since the LD equation gives equal or improved accuracy over the installation equations, it would seem to be the method of choice for major command level energy consumption predictions.

Typical Results From DESCOM Equations

Inspection of the DESCOM equations reveals that DESCOM energy consumption depends on HDD, cooling degree days (CDD), hourly measures of production, and total labor force. Like the AMCCOM equations, the DESCOM equations were used to estimate FY84 energy consumption. Figure 7 gives the results. Efforts to apply lumped data regression to DESCOM data are currently under way.

4 INSTALLATION LEVEL EQUATIONS

Vol II of this report lists installation equations and related statistics. Equations are given for total consumption of facility energy, heating fuel, electrical energy, and mobility fuel.

Generally, energy consumption predictions for individual installations are not as good as for the major command level. This is because of the averaging effect which occurs in calculating the overall command energy consumption. Figure 8 is a plot of predicted versus actual energy consumption for Holston AAP. The accuracy is on the order of $\pm$ 10 percent. In some cases, errors for predictions of monthly energy consumption are as great as $\pm$ 30 percent; however, accuracy improves in predictions for quarterly and yearly energy consumption. Tables 8 and 9 summarize quarterly and annual energy consumptions for FY84 for AMCCOM and DESCOM installations, respectively.

Accuracy of Equations

A regression equation is only as good as the data used to develop it. Even stating that data is good or bad is misleading, since "good" data (that is, data which accurately represent the situation) can be very disperse.

It is often desirable to determine how far from the true value a predicted value is likely to be. This is done by using confidence limits (Figure 9). This figure shows 95 percent confidence limits for the mean and individual observations for a single-variable equation. The outer confidence limits define a region about the equation in which 95 percent of individual observations are expected to fall. The inner confidence limits define a region where there is 95 percent confidence that the average of repeated observations will fall. The 95 percent confidence intervals for any installation equation can be determined using the equations below.

95 Percent Confidence Interval For The Mean (CIM):

$$\text{CIM} = \widehat{\text{MBTU}} \pm \Delta\,(\text{MBTU})_M$$

where for AMCCOM:

$$\Delta\,(\text{MBTU})_M = t\,(n - p,\ 0.975)\ \Big\{\frac{\sigma^2}{n} + (\text{HDD} - \overline{\text{HDD}})^2\sigma_{B_1}^2 + (\text{LBRFRC} - \overline{\text{LBRFRC}})^2\sigma_{B_2}^2 - 2\,(\text{HDD} - \overline{\text{HDD}})\,(\text{LBRFRC} - \overline{\text{LBRFRC}})\,\sigma_{B_1}\sigma_{B_2}r_{HL}\Big\}^{1/2}$$

and for DESCOM:

$$\Delta\,(\text{MBTU})_M = t\,(n - p,\ 0.975)\ \Big\{\frac{\sigma^2}{n} + (\text{HDD} - \overline{\text{HDD}})^2\sigma_{B_1} + (\text{OTHER} - \overline{\text{OTHER}})^2\sigma_{B_2}^2 - 2\,(\text{HDD} - \overline{\text{HDD}})\,(\text{OTHER} - \overline{\text{OTHER}})\,\sigma_{B_1}\sigma_{B_2}r_{HO}\Big\}^{1/2}$$

95 Percent Confidence Interval for Individual Observations (CII):

$$CII = \widehat{MBTU} \pm \Delta\ (MBTU)_I$$

where for AMCCOM:

$$\Delta\ (MBTU)_M = t\ (n - p,\ 0.975)\ \{\frac{\sigma^2}{n} + (HDD - \overline{HDD})^2\sigma^2_{B_1} + (LBRFRC - \overline{LBRFRC})^2\sigma^2_{B_2} - 2\ (HDD - \overline{HDD})\ (LBRFRC - \overline{LBRFRC})\ \sigma_{B_1}\sigma_{B_2} r_{HL}\}^{1/2}$$

and for DESCOM:

$$\Delta\ (MBTU)_M = t\ (n - p,\ 0.975)\ \{\frac{\sigma^2}{n} + (HDD - \overline{HDD})\sigma_{B_1} + (OTHER - \overline{OTHER})^2\sigma^2_{B_2} - 2\ (HDD - \overline{HDD})\ (OTHER - \overline{OTHER})\ \sigma_{B_1}\sigma_{B_2} r_{HO}\}^{1/2}$$

The symbols used in the above equations are defined as follows:

$\widehat{MBTU}$ = predicted value of MBTU.

$t(n-p,\ 0.975)$ = 97.5 precentage point of a t-distribution with (n-p) degrees of freedom.

n = number of observations on which the regression equation is based.

p = number of nonzero coefficients in the regression equation (including the intercept).

σ^2 = mean square error.

$\overline{HDD}$ = average HDD for the data on which the regression equation is based.

$\overline{LBRFRC}$ = average LBRFRC for the data on which the regression equation is based.

$\overline{OTHER}$ = average OTHER for the data on which the regression equation is based.

σ_{B_1} = standard error of B1.

σ_{B_2} = standard error of B2.

r_{HL} = HDD/LBRFRC correlation coefficient.

r_{HO} = HDD/OTHER correlation coefficient.

Tables 4 and 5 provide data for confidence interval calculations.

Sample Calculation

Indiana AAP had the following values of HDD and LBRFRC during March 1984:

$$HDD = 458$$
$$LBRFRC = 1849$$

Calculate 95 percent confidence intervals for the mean and for individual observations.

The following data are obtained from Table 4:

$$n = 96$$

$$BO = 3526.2$$

$$\sigma_{BO} = 1779.6$$

$$B1 = 38.3$$

$$\sigma_{B_1} = 1.3$$

$$B2 = 8.2$$

$$\sigma_{B_2} = 1.1$$

$$\overline{HDD} = 485.1$$

$$\overline{LBRFRC} = 1498.0$$

$$r_{HL} = 0.04996$$

$$\sigma^2 = 35822883.6$$

Also, since there are three nonzero coefficients (BO, B1, B2),

$$p = 3.0$$

From t distribution tables:

$$t\ (96-3,\ 0.975) = t\ (93,\ 0.975) = 1.986$$

$$\widehat{MBTU} = 3526.2 + (38.3)\ (458) + (8.2)\ (1849) = 36229.4$$

$$\Delta\ (MBTU)_M = (1.986)\ \{\ (35822883.6)\ /\ (96)$$

$$+ (458-485.1)^2\ (1.3)^2 + (1849-1498)^2\ (1.1)^2$$

$$- (2)\ (458-485.1)\ (1849-1498)\ (1.3)\ (1.1)\ (0.04996)\ \}^{\frac{1}{2}}$$

$$= 741.0$$

$$\Delta\ (MBTU)_I = (1.986)\ \{\ (35822883.6)$$

$$+ (35822883.6) / (96) + (458-485.1)^2 (1.3)^2$$

$$+ (1849-1498)^2 (1.1)^2 - (2)(458-485.1)(1849-1498)(1.3)(1.1)(0.04996)\}^{\frac{1}{2}}$$

$$= 11909.7$$

Therefore:

$$CIM = 36229.4 \pm 741.0$$

$$CII = 36229.4 \pm 11909.7$$

Figure ˙0 gives the results of repeating the above calculations for the other 11 months of FY84 for Indiana AAP. The confidence interval for the mean is given by the vertical distance between LCLM and UCLM, and the confidence interval for individual observations is given by the vertical distance between LCLI and UCLI. Confidence limits are very useful for setting goals and measuring goal compliance, because any given installation equation represents the installation's current energy consumption characteristics. The significance of changes in energy consumption can therefore be assessed by comparing them with the appropriate confidence limit. For example, if the energy reduction goal was made to coincide with the lower confidence limit, only consumption rates lower than this limit would be statistically significant.

5 CONCLUSIONS AND RECOMMENDATIONS

The results of the regression analysis of AMCCOM and DESCOM data indicate that the equations developed in this study provide an accurate model of energy consumption for these two major AMC subcommands. The model is a useful indicator of the weather and production parameters which affect AMCCOM, DESCOM, and AMC energy consumption. The generation of confidence limits made possible by this model provides a means of setting and evaluating energy conservation goals, since an installation's equation represents its current energy consumption characteristics.

It is recommended that AMC use these equations as a tool for setting energy conservation goals, measuring goal compliance, and managing energy conservation activities.

Table 1

Regression Variables--DESCOM and AMCCOM
(Metric Conversion Factor: °C = [°F-32] [5/9].)

DESCOM

Variable	Description	Source of Data
MBTU	Total depot energy consumption	LSSA DEIS I & II
ELEC	Total (purchased + generated) depot electrical energy consumption	LSSA DEIS I & II
NATGAS	Depot natural gas consumption	LSSA DEIS I & II
COAL	Depot coal consumption	LSSA DEIS I & II
FSX	Depot fuel oil consumption	LSSA DEIS I & II
PPG	Depot propane consumption	LSSA DEIS I & II
MOGAS	Depot mobility gas consumption	LSSA DEIS I & II
HTGMBTU	Depot consumption of heating fuels: natural gas, coal, and fuel oil	LSSA DEIS I & II
ELECADJ	Depot electrical energy consumption adjusted for facility changes	LSSA DEIS I & II Energy Plan
HTGADJ	Depot consumption of heating fuels adjusted for facility changes	LSSA DEIS I & II Energy Plan
MBTUADJ	Total depot energy consumption adjusted for facility changes	LSSA DEIS I & II Energy Plan
TIME	Number of months since September 1974 for a given observation	--
QTIME	Number of quarters since September 1974 for a given observation	--
HDD	Facility heating degree days (Base 65°F)	NOAA
CDD	Facility cooling degree days (Base 65°F)	NOAA
LBRFRC	Labor Force Strength	From Depots
SUPPHR	Supply manhours	Depot Opn. Cost & Performance Report (CRCS DRCMM-305)

Table 1 (Cont'd)

Variable	Description	Source of Data
MAINTHR	Maintenance manhours	DESCOM Product
TOTHR	Total manhours	SUPPHR +
MAINTHR		
UNITS	Total number of items shipped/received	RCS DRCMM-305
TONS	Total weight of items shipped/received (tons)	RCS DRCMM-305
nREPAIRS	Number of nth class of items repaired	PCN K45BBY9ET40
REPAIRS	Total number of items repaired	PCN K45BBY9ET40
	AMCCOM	
MBTU	Total installation energy consumption	LSSA DEIS I & II
ELEC	Total (purchased + generated) installation electrical energy consumption	LSSA DEIS I & II
NATGAS	Installation natural gas consumption	LSSA DEIS I & II
COAL	Installation coal consumption	LSSA DEIS I & II
FSX	Installation fuel oil consumption	LSSA DEIS I & II
PPG	Installation propane consumption	LSSA DEIS I & II
MOGAS	Installation mobility gas consumption	LSSA DEIS I & II
HTGMBTU	Installation consumption of heating fuels: natural gas, coal, and fuel oil	LSSA DEIS I & II
ELECADJ	Installation electrical energy consumption adjusted for facility changes	LSSA DEIS I & II & Installation Energy Plan
HTGADJ	Installation consumption of heating fuels adjusted for facility changes	LSSA DEIS I & II & Installation Energy Plan
MBTUADJ	Total installation energy consumption adjusted for facility changes	LSSA DEIS I & II & Installation Energy Plan
MBTU1YR	Total installation energy consumption one year prior to current observation	LSSA DEIS I & II

Table 1 (Cont'd)

Variable	Description	Source of Data
TIME	Number of months since September 1974 for a given observation	--
QTIME	Number of quarters since September 1974 for a given observation	--
HDD	Facility heating degree days (Base 65°F)	NOAA
CDD	Facility cooling degree days (Base 65°F)	NOAA
LBRFRC	Labor force strength	Contractor Labor Force Summary, Accounting
TOTHRS	Total manhours	Personnel Utilization Report (PUR)
DIRHR	Direct manhours	PUR, Personnel Standards Coverage Report (PSCR)
INDHR	Indirect manhours	PUR, PSCR
UNITS	Total number of items produced	Derived from 501
TOTWT	Total weight of items produced	Derived from 501, Tech. Manuals
NUMn	Number of nth class of items produced	Derived from 501
WTn	Weight of nth class of items produced	Derived from 501, Tech. Manuals

Table 2

Installation Energy Consumption Weather Station Location and Total Floor Area (Metric Conversion Factor: 1 sq ft = 0.09 m^2)

Installation	Energy Consumption (GBTU) FY82	Weather Data Location	Total Floor Area (Million sq ft)
Arsenals			
PA	1795.	Allentown, PA	4.1
PBA	449.05	Little Rock, AR	3.3
RIA	1391.	Moline, IL	2.0
WA	865.3	Albany, NY	2.2
HA	412.76	Bishop, CA	10.2
Active AAPs*			
HOLAAP	3741.6	Bristol, TN	2.4
INDAAP	417.56	Indianapolis, IN	4.7
IAAP	1094.7	Burlington, IA	4.3
KAAP	199.99	Wichita, KS	2.2
LCAAP	1229.8	Kansas City, MO	3.2
LSAAP	628.8	Shreveport, LA	3.1
LAAP	582.8	Shreveport, LA	1.39
LOUAAP	520.2	Shreveport, LA	2.74
MCAAP	427.64	Fort Smith, AR	9.3
MAAP	403.11	Nashville, TN	3.7
RAAP	4685.1	Roanoke, VA	3.6
RIVAAP	55.64	Stockton, CA	0.8
SAAP	721.3	Scranton/Wilkes-Barre, PA	0.4
SUNAAP	632.72	Wichita, KS	3.47
TCAAP	808.3	Minneapolis-St. Paul, MN	4.5
Inactive AAPs			
BAAP	151.28	LaCrosse, WI	4.2
CAAP	33.065	Grand Island, NB	2.0
TAAP	376.31	Chicago, IL	5.2
NAAP	163.38	New Orleans, LA	1.1
RAVAAP	105.31	Indianapolis, IN	5.0
VAAP	64.97	Youngstown, OH	1.1
MISSAAP	NA	Chattanooga, TN	1.3

*AAP = Army Ammunition Plant.

Table 3

Depot Energy Consumption, Weather Data, and Total Floor Area (Metric Conversion Factor: 1 sq ft = .09 m^2)

Depot	FY82 Energy Usage (GBTU)	HDD	CDD	NOAA Weather Station	Total Floor Area (Million sq ft) Gross FY75	Gross FY84	Heated FY75	Heated FY84
ANAD	1,139	2,863	1,881	Birmingham, AL	8.16	8.41	1.73	2.08
CCAD	971	970	3,574	Corpus Christi, TX	1.61	1.97	1.61	1.97
FWDA	35	4,414	1,254	Albuquerque, NM	1.99	1.99	4.32	0.32
LEAD	684	5,335	1,006	Harrisburg, PA	6.86	6.96	2.78	2.88
LBDA	441	4,814	1,170	Lexington, KY	5.41	5.77	2.10	2.11
NCAD	884	5,815	751	Allentown, PA	5.32	5.56	4.47	4.50
PUDA	348	5,465	1,042	Pueblo, CO	6.24	6.24	1.24	1.24
RRAD	1,060	2,269	2,444	Shreveport, LA	6.44	7.26	2.82	3.19
SAAD	401	2,772	1,198	Sacramento, CA	2.84	3.00	2.69	2.86
SVDA	177	6,498	899	Moline, IL	4.43	4.41	0.91	0.91
SEAD	340	6,787	506	Syracuse, NY	4.43	4.56	0.92	0.72
SHAD	167	2,674	1,448	Stockton, CA	3.16	3.22	0.70	0.72
SIAD	258	6,030	357	Reno, NV	4.98	5.42	0.75	0.94
TOAD	802	6,330	569	Scranton, PA	3.46	3.74	3.43	3.71
TEAD	873	5,802	981	Salt Lake City, UT	7.05	7.43	3.53	3.81
UMDA	73	5,263	726	Pendleton, OR	3.36	3.44	0.35	0.35
DESCOM	8,653	-----	---		75.74	79.38	34.35	32.31

Table 4

AMCCOM Equations and Data for 95 percent Confidence Limit Calculations
General Equation: MBTU = B0 + B1 * HDD + B2 * LBRFRC

Installation	No. Obs.	B0	Sigma B0	B1	Sigma B1	B2	Sigma B2	Average HDD	Average LBRFRC	HDD/LBRFRC Correlation	Sigma Squared
Picatinny	96	103792.8	3237.4	92.8	5.0	0	0	478.2	NA*	NA	453019578.2
Pine Bluff	95	29786.8	1167.2	42.3	2.9	0	0	267.7	NA	NA	7611290.5
Rock Island	29	88021.8	3219.7	71.0	4.3	0	0	559.7	NA	NA	133393198.4
Watervliet	96	43454.4	1355.9	43.5	1.8	0	0	588.5	NA	NA	71688445.6
Iowa	96	54103.0	3215.8	98.6	4.4	0	0	531.8	NA	NA	473438229.4
Kansas	96	11989.4	916.3	25.2	1.6	0	0	403.4	NA	NA	41633971.1
Lone Star	96	45707.4	2280.0	94.6	7.2	0	0	200.7	NA	NA	296488293.1
McAlester	96	16056.4	943.8	53.9	2.1	0	0	308.3	NA	NA	46916879.6
Milan	83	21494.0	1328.2	50.7	2.8	0	0	321.6	NA	NA	79086360.1
Cornhusker	96	943.7	106.3	4.2	0.1	0	0	543.8	NA	NA	507173.0
Newport	96	6125.0	523.6	17.3	0.8	0	0	485.1	NA	NA	12627183.2
Badger	96	-39558.7	3399.8	26.9	2.7	174.6	7.7	633.1	313.1	-0.02500	238467578.5
Sunflower	96	-41053.1	5276.6	34.4	4.3	158.6	11.7	403.4	381.8	-0.10645	306696699.0
Twin Cities	96	26201.4	1579.6	39.5	1.6	105.0	3.3	662.6	268.4	0.13315	83314250.1
Joliet	96	-82251.3	6892.9	40.1	5.8	307.5	11.4	555.2	470.2	0.00096	806592863.8
Ravenna	96	-304.0	901.1	8.8	0.3	26.7	4.3	560.6	193.5	-0.17700	2398377.1
Volunteer	96	-80138.3	6258.9	27.1	8.7	438.8	18.1	307.0	292.9	0.13859	751539522.6
Holston	81	-351917.0	15886.1	87.4	8.1	602.6	13.3	374.5	1161.6	0.04992	675615070.7
Indiana	96	3526.2	1779.6	38.3	1.3	8.2	1.1	485.1	1498.0	0.04996	35822883.6
Lake City	84	19256.7	9113.5	55.5	2.4	29.8	4.6	458.3	1942.0	-0.01289	106106838.7
Long Horn	95	16245.3	3752.4	37.6	2.4	35.1	4.6	200.7	809.2	0.08160	31309924.4
Louisiana	96	-47322.5	6234.8	43.0	2.8	96.8	7.6	200.7	812.3	-0.05770	43889492.0
Radford	96	-86411.0	29887.9	171.5	10.1	134.3	10.6	378.0	2805.1	0.07425	1281655363.0

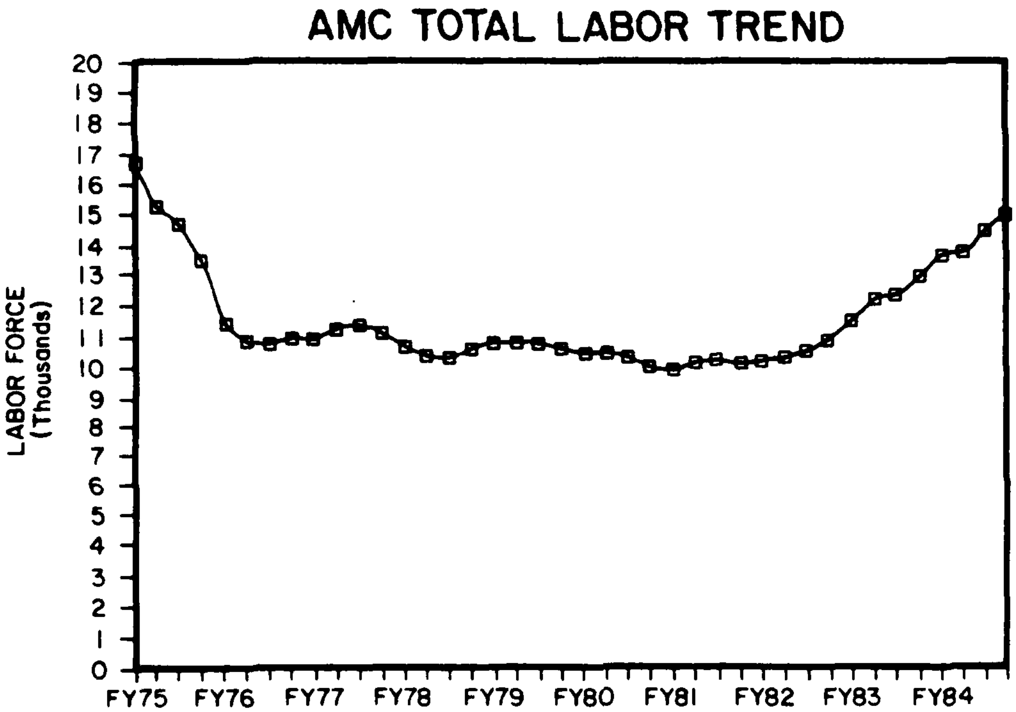
*NA = Not applicable.

Table 5

DESCOM Equations and Data for 95 percent Confidence Limit Calculations
General Equation: MBTU = B0 + B1 * HDD + B2 * Other

Installation	No. Obs.	B0	Sigma B0	B1	Sigma B1	B2	Sigma B2	Average HDD	Average Other	HDD/LBRFRC Correlation	Sigma Squared
Anniston	34	58458.0	38310.2	67.7	4.6	188.9	43.1	766.0	867.4	-0.17901	355717699.0
Letterkenny	34	198971.0	5022.1	51.2	2.8	0	0	1402.9	NA	NA*	332916758.0
Lexington-BG	34	49537.0	5040.3	38.9	2.0	70.2	12.8	1260.8	298.6	-0.01652	148852536.0
New Cumberland	38	151466.0	4627.3	55.4	2.5	0	0	1461.9	NA	NA	306094260.0
Pueblo	17	40874.0	6171.7	26.0	3.1	174	31.8	1436.8	93.7	-0.00019	159252663.0
Red River	37	237594.0	5895.0	76.1	6.7	0	0	627.7	NA	NA	631352225.0
Savanna	31	10359.0	2224.8	19.5	1.0	0	0	1697.8	NA	NA	64089167.0
Seneca	32	48267.0	2801.5	21.2	1.3	0	0	1757.3	NA	NA	84146021.0
Sharpe	23	-9400.0	10939.1	12.0	1.6	28.8	7.4	644.3	1449.7	-0.13018	14665759.0
Sierra	33	41212.0	1386.7	15.2	0.8	0	0	1475.7	NA	NA	17464327.0
Tobyhanna	37	104298.0	5630.0	65.1	2.8	0	0	1612.3	NA	NA	418714952.0

*NA = Not applicable.



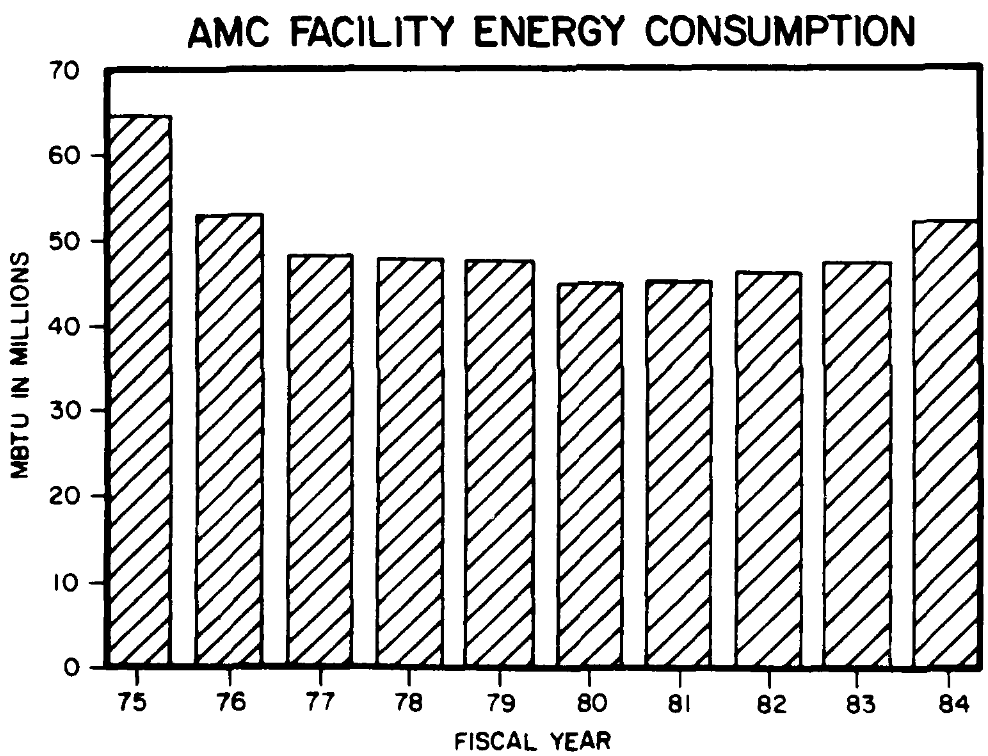


Figure 1. Comparison of AMCCOM force trends with energy consumption.

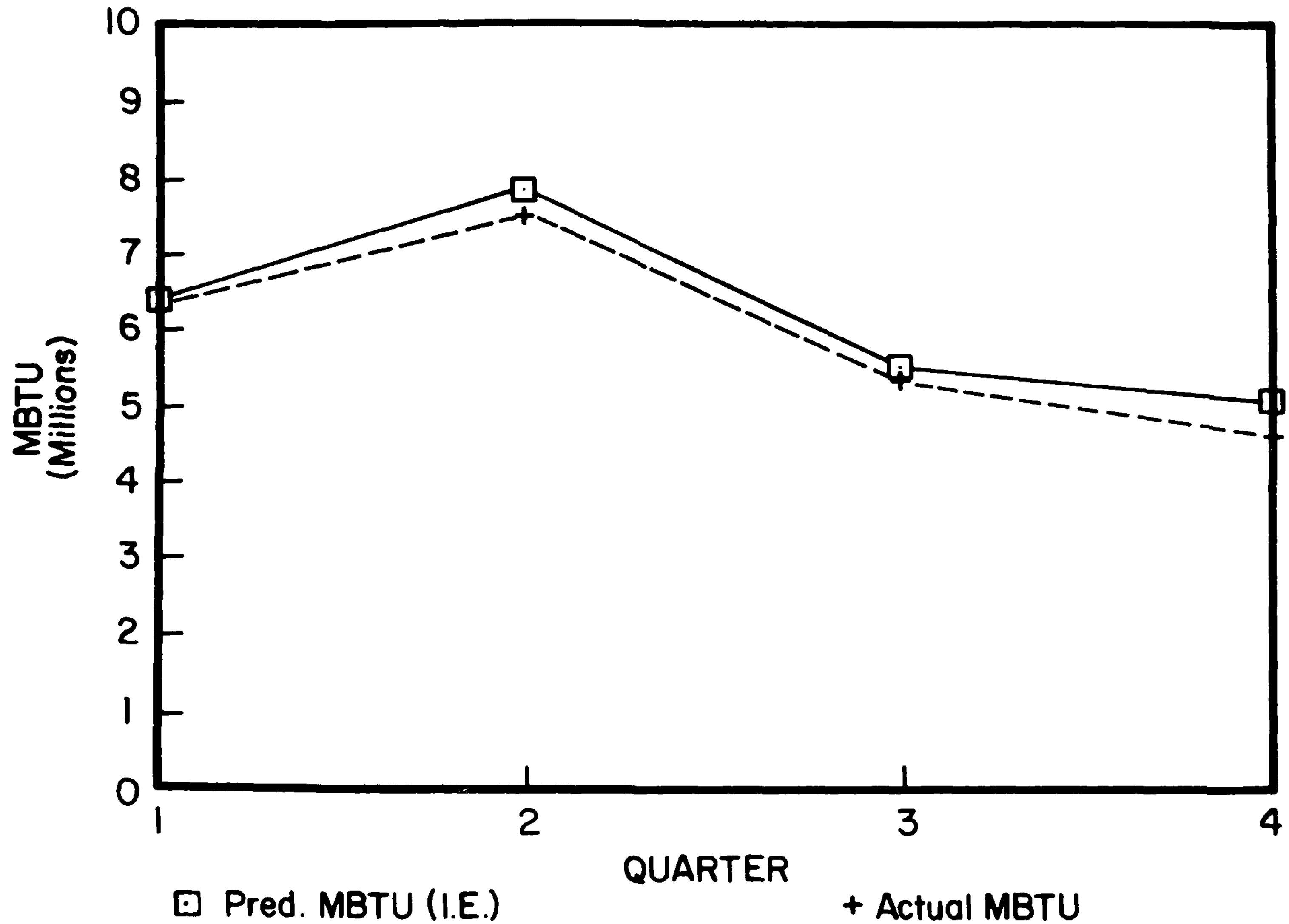


Figure 2. AMCCOM FY84 Energy Consumption Prediction.

Table 6

Lumped Data Regression Analysis

HDD Installations

FY Range	B_0	B_1	R^2
75-82	424049.5	54.3	0.918
76-82	412214.3	54.3	0.930
77-82	404522.0	53.1	0.949
78-82	396575.1	53.5	0.949
79-82	388293.1	54.1	0.946
80-82	379309.2	52.6	0.973
81-82	372916.4	52.8	0.974
82	377511.3	51.7	0.975

HDD/LBRFRC Installations

FY Range	B_0	B_1	B_2	R^2
75-82	-716647.0	51.6	152.9	0.854
76-82	-41042.8	49.2	86.2	0.693
77-82	148649.8	45.3	64.5	0.879
78-82	721575.2	42.3	13.3	0.940
79-82	653573.6	42.8	18.8	0.940
80-82	674731.7	43.5	16.8	0.938
81-82	861242.2	41.9	2.1	0.932
82	885947.6	41.3	0.3	0.931

Table 7

Lumped Data MBTU Predictions: AMCCOM FY 84

FY Range	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
75-82	7278244	8664125	6284494	5831345
76-82	6453648	7805167	5388062	4934582
77-82	6009418	7292966	4969986	4536799
78-82	5525726	6770828	4441216	4012454
79-82	5543861	6803549	4454783	4022014
80-82	5489161	6740085	4405652	3974936
81-82	5389317	6619381	4301209	3875415
82	5377464	6586338	4305647	3886741

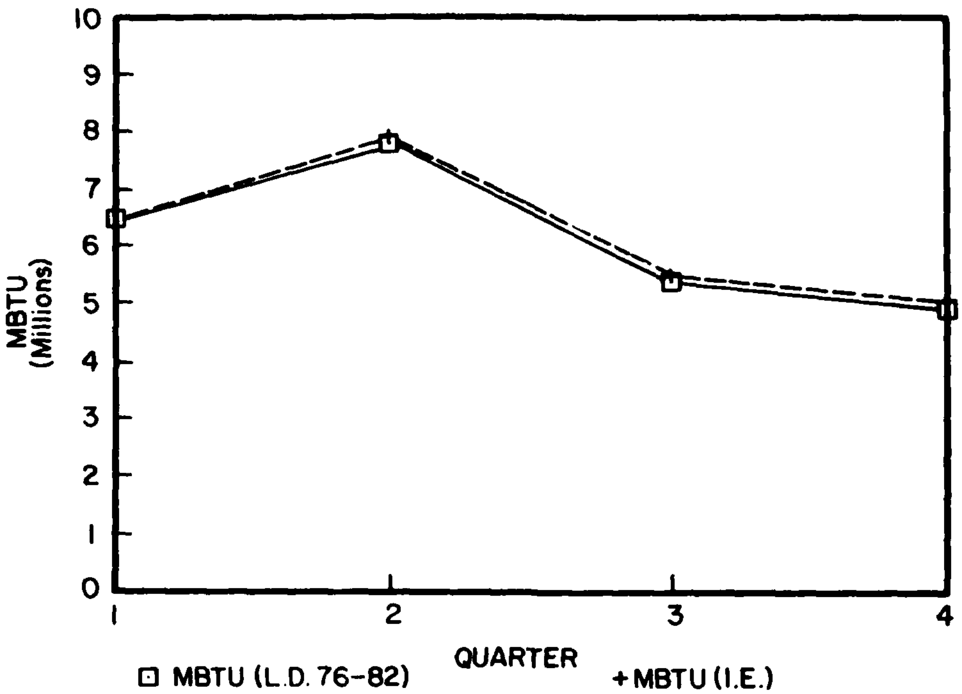


Figure 3. Total AMCCOM energy consumption predictions for FY84.

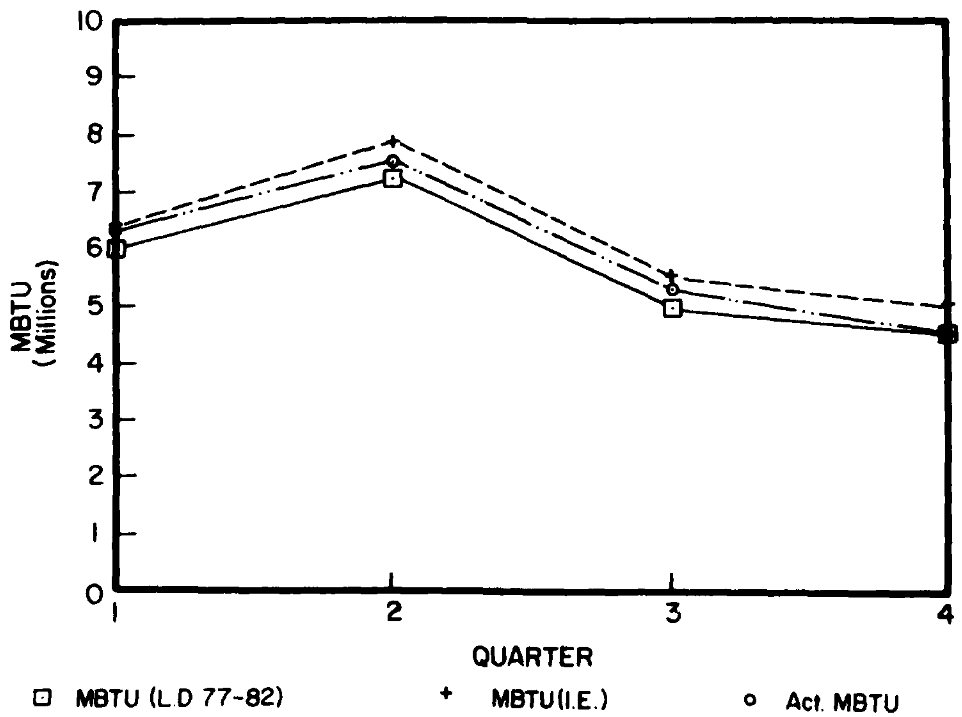


Figure 4. Actual AMCCOM energy consumption for FY84.

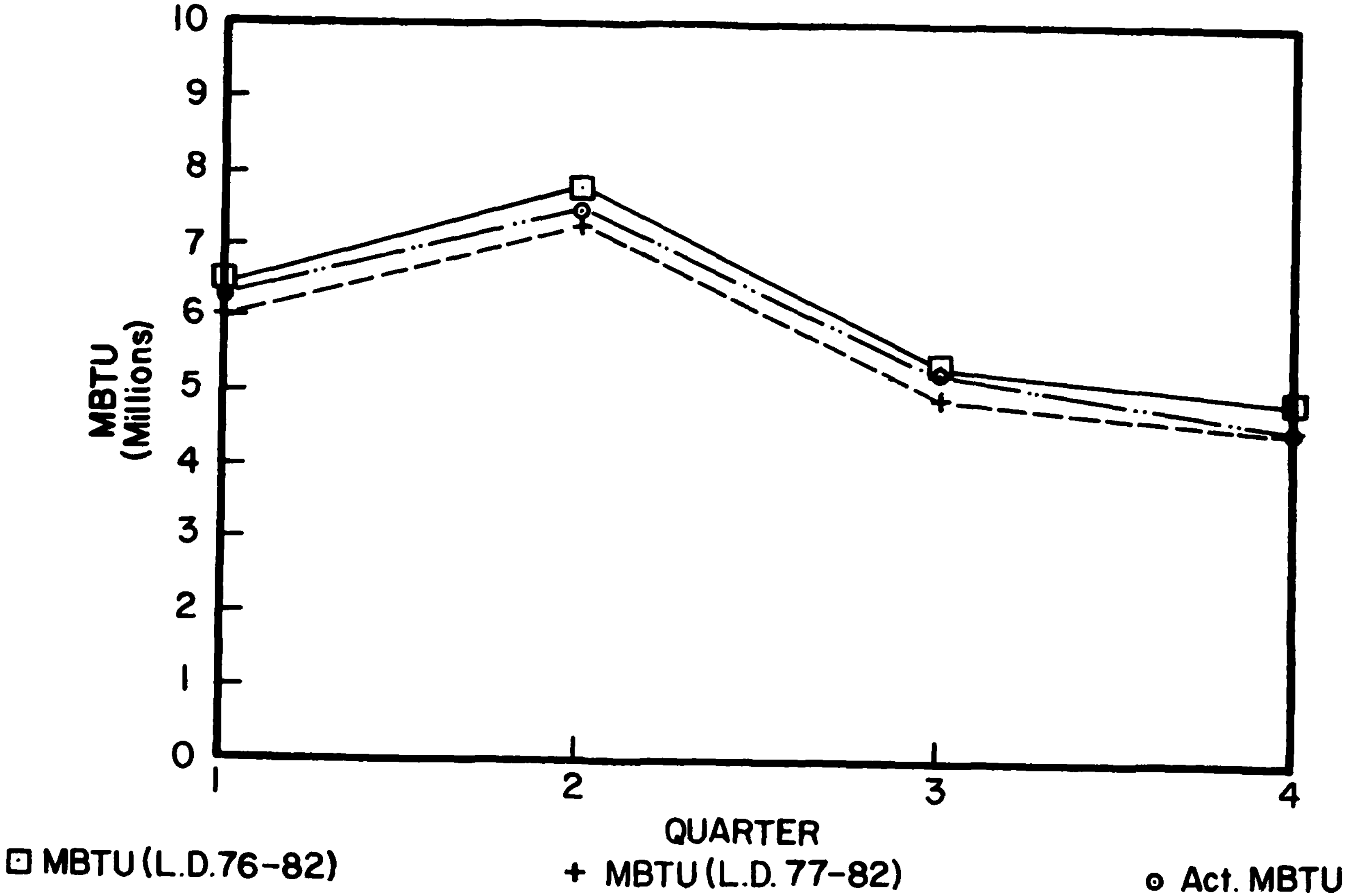


Figure 5. LD 76-82 and LD 77-82 equations vs. actual energy use (AMCCOM).

Table 8

AMCCOM Data - FY84—Predicted and Actual Values of MBTU

Installation	1st Qtr. Predicted	1st Qtr. Actual	2nd Qtr. Predicted	2nd Qtr. Actual	3rd Qtr. Predicted	3rd Qtr. Actual	4th Qtr. Predicted	4th Qtr. Actual	Total Predicted	Total Actual	Actual/ Predicted
Badger	72606	33944	70703	37347	58701	19111	32147	11193	234157	101595	0.434
Cornhusker	12718	9301	16200	12784	5687	5399	3327	2890	37931	30374	0.801
Holston	1063009	1045015	1286127	1120586	1166261	952099	1099970	892961	4615367	4010661	0.869
Indiana	105649	101103	154725	161831	71384	70848	57749	63015	389506	396797	1.019
Iowa	355959	285407	489661	417400	222751	156940	170000	101354	1238371	961101	0.776
Joliet	94610	131582	143304	146605	75366	97474	42910	46106	356190	421767	1.184
Kansas	73415	66918	102471	78660	45343	40449	36775	38466	258004	224493	0.870
Lake City	409138	383044	492856	468275	364121	347893	342155	282685	1608270	1481897	0.921
Lone Star	183571	222579	282901	284166	143744	177773	137122	157934	747338	842452	1.127
Longhorn	165257	154473	200831	180264	150561	133314	148350	131789	664998	599840	0.902
Louisana	284971	202664	321844	265975	259471	212327	257720	193206	1124006	874172	0.778
Milan	117869	100308	193564	171493	72239	72086	64837	64629	448509	408516	0.911
Newport	45951	45775	71797	59271	28011	25698	19551	15303	165311	146047	0.883
Picatinny	477954	515369	590614	576372	360006	376649	314998	316450	1743571	1784840	1.024
Pine Bluff	129799	164991	174045	203018	96128	106744	89572	124689	489545	599442	1.224
Radford	1568530	1727611	1735144	1894024	1375516	1555371	1344694	1251457	6023883	6428463	1.067
Ravenna	28862	35425	40328	42717	19598	26617	14134	14090	102923	118849	1.155
Rock Island	412029	408565	510861	517646	309505	326161	270455	288661	1502852	1541033	1.025
Sunflower	307189	201568	346029	293113	281711	249665	273171	254850	1208099	999196	0.827
Twin Cities	220289	209684	277693	251478	178192	150107	142538	133313	818712	744582	0.909
Volunteer	63488	17239	85658	22055	39250	14414	20915	12400	209310	66108	0.316
Watervliet	219103	250217	274044	308103	166686	207547	137584	167525	797417	933392	1.171
Totals	6411966	6312782	7861401	7513183	5490230	5324686	5020673	4564966	24784269	23715617	0.957

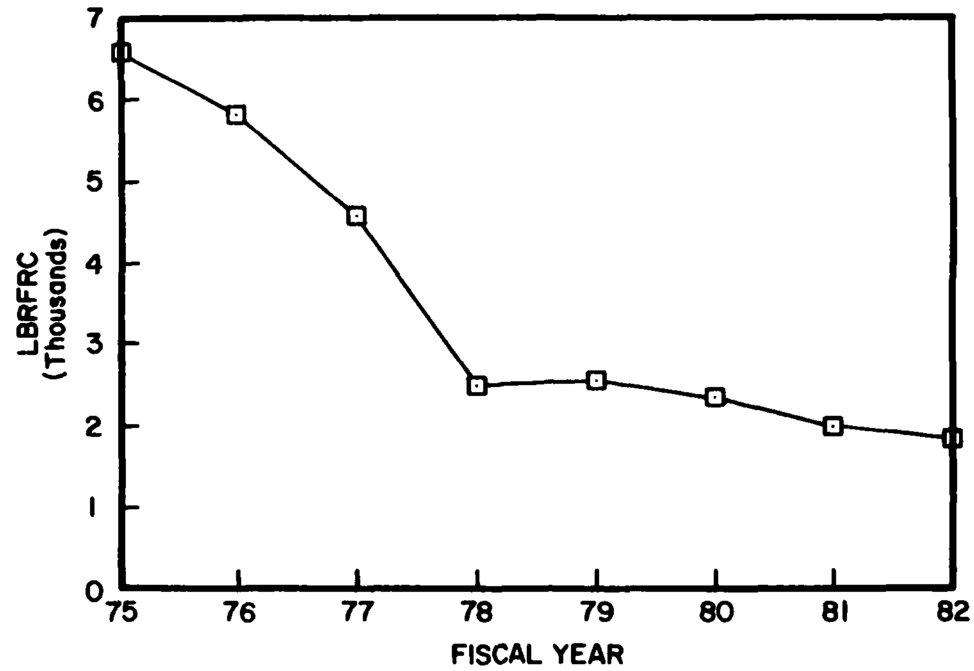


Figure 6. Volunteer AAP production levels.

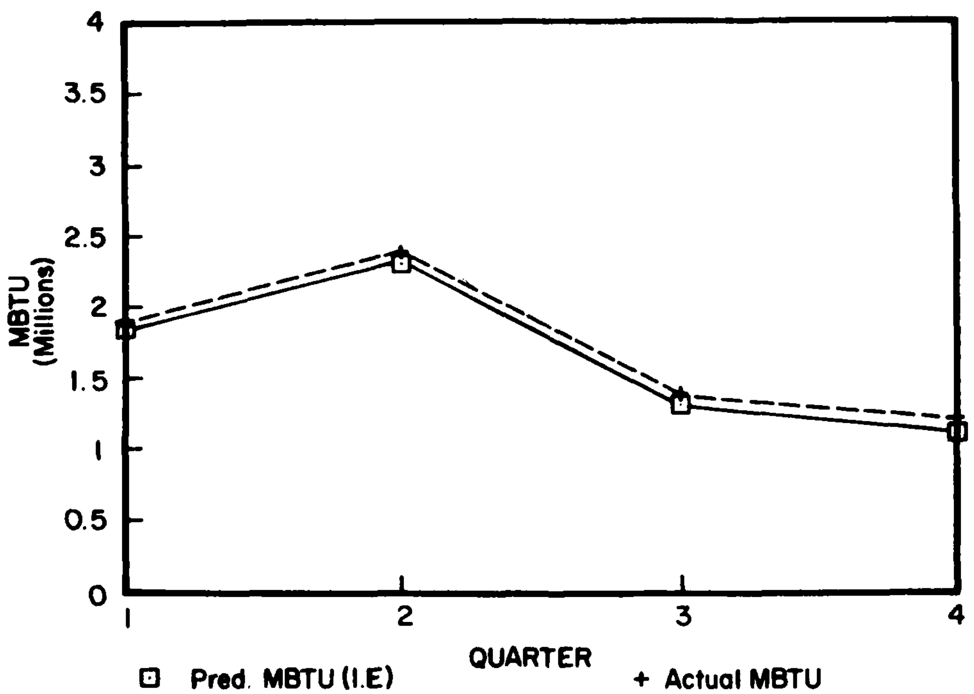


Figure 7. LDD 76-82 and LD 77-82 equations vs. actual energy use (DESCOM).

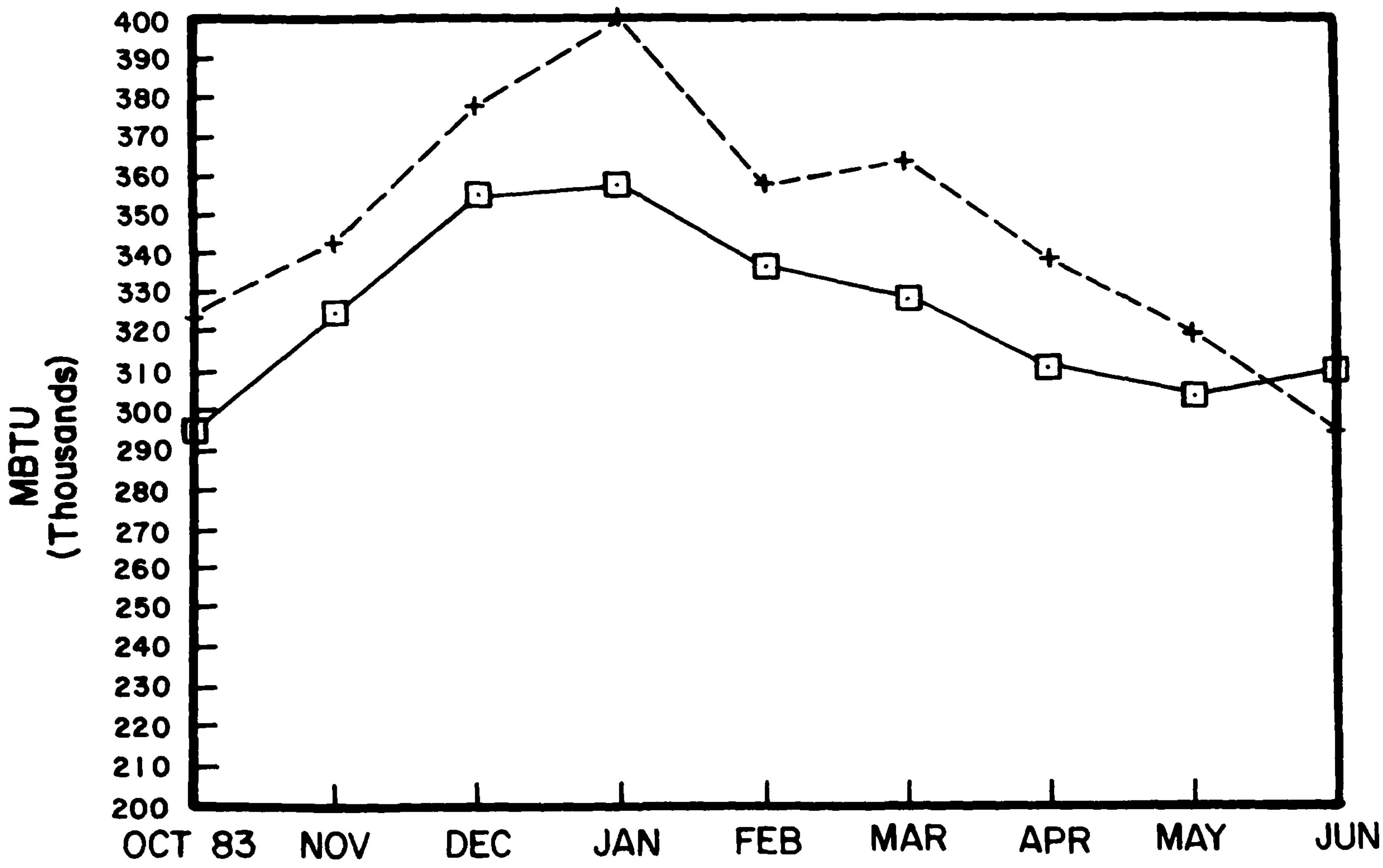


Figure 8. Predicted vs. actual energy consumption for Holston AAP.

Table 9

DESCOM Data - Fy 84—Predicted and Actual Values of MBTU

Installation	1st Qtr. Predicted	1st Qtr. Actual	2nd Qtr. Predicted	2nd Qtr. Actual	3rd Qtr. Predicted	3rd Qtr. Actual	4th Qtr. Predicted	4th Qtr. Actual	Total Predicted	Total Actual	Actual/ Predicted
Anniston	286763	292411	347519	381056	237486	252428	221507	253724	1093275	1179619	1.079
Letterkenny	285550	286241	341307	341088	224469	239781	201582	212487	1052908	1079597	1.025
Lexington-BG*	144266	126949	197433	195369	NA	93151	NA	70460	341700	322318	0.943
New Cmbrland	233569	257726	297113	304491	179055	177126	154291	145966	864028	885309	1.025
Pueblo	103670	92860	123846	129111	71534	76539	52346	41252	351396	339762	0.967
Red River	274959	328935	340633	417194	242921	278359	237594	293081	1096108	1317569	1.202
Savanna	53025	54889	77693	74049	21221	21525	11685	12702	163623	163165	0.997
Seneca	93783	98983	122361	128051	66775	82677	51426	63694	334345	373405	1.117
Sharpe	49131	40113	53758	46282	60402	31801	36229	30260	199520	148456	0.744
Sierra	79151	69817	84988	85637	49116	57535	41957	48442	255212	261431	1.024
Tobyhanna	242505	242066	335078	285850	152602	166909	113477	107473	843662	802298	0.951
Totals	1846374	1890990	2321728	2388178	1305580	1384680	1122094	1209081	6595776	6872929	1.042

*Lexington-BG data for 3rd and 4th quarters not included in any totals.

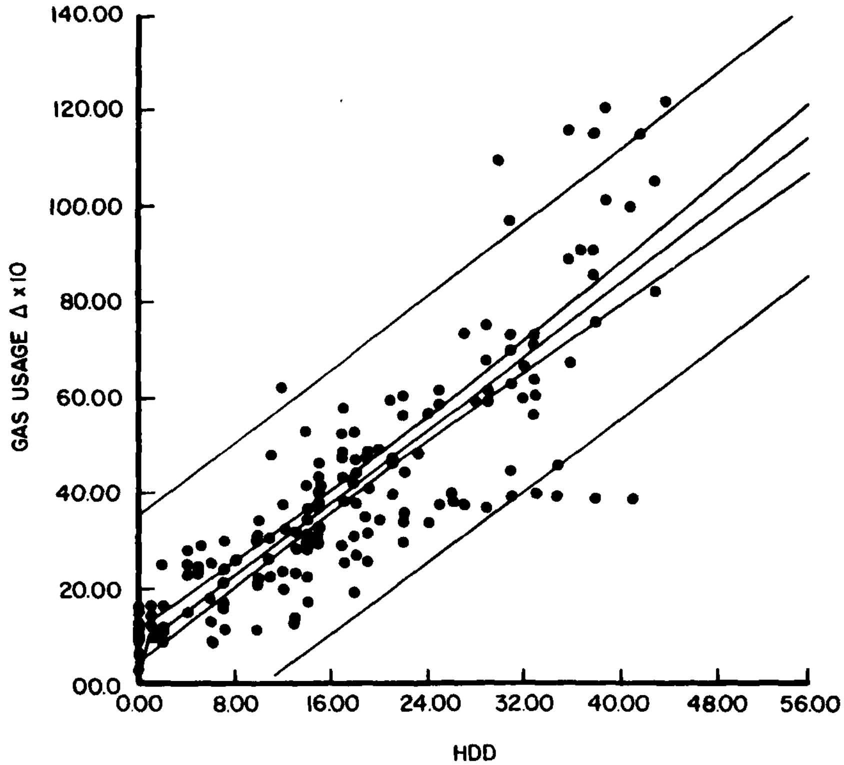


Figure 9. Concept of Confidence Limits.

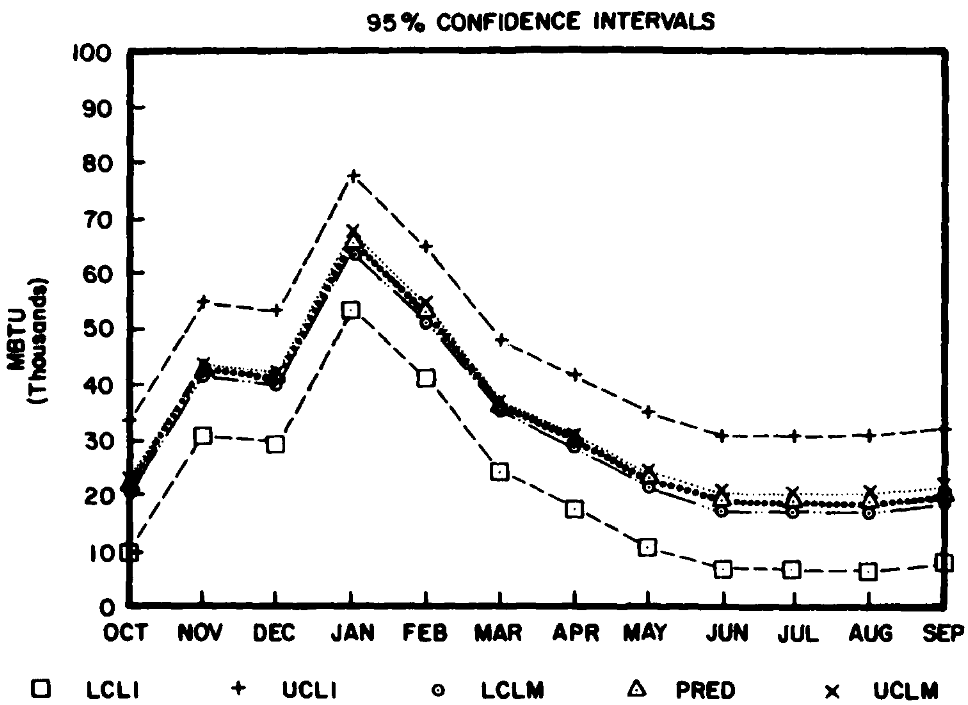


Figure 10. Confidence intervals for Indiana AAP.

USA-CERL DISTRIBUTION

Chief of Engineers
ATTN: AMCEN-C/Mr. L. Aveta
ATTN: DAEN-ASI-L (2)
ATTN: DAEN-CCP
ATTN: DAEN-CW
ATTN: DAEN-CWE
ATTN: DAEN-CWM-R
ATTN: DAEN-CWO
ATTN: DAEN-CWP
ATTN: DAEN-EC
ATTN: DAEN-ECC
ATTN: DAEN-ECE
ATTN: DAEN-ECR
ATTN: DAEN-RD
ATTN: DAEN-RDC
ATTN: DAEN-RDM
ATTN: DAEN-RM
ATTN: DAEN-ZCE
ATTN: DAEN-ZCF
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM
ATTN: DAEN-ZCZ

FESA, ATTN: Library 22060
ATTN: DET III 79906

US Army Engineer Districts
ATTN: Library (41)

US Army Engineer Divisions
ATTN: Library (14)

US Army Europe
AEAEN-ODCS/Engr 09403
ISAE 09081
V Corps
ATTN: DEH (11)
VII Corps
ATTN: DEH (15)
21st Support Command
ATTN: DEH (12)
USA Berlin
ATTN: DEH (11)
USASETAF
ATTN: DEH (10)
Allied Command Europe (ACE)
ATTN: DEH (3)

8th USA, Korea (19)

ROK/US Combined Forces Command 96301
ATTN: EUSA-HHC-CFC/Engr

USA Japan (USARJ)
ATTN: AJEN-DEH 96343
ATTN: DEH-Honshu 96343
ATTN: DEH-Okinawa 96331

416th Engineer Command 60623
ATTN: Facilities Engineer

US Military Academy 10966
ATTN: Facilities Engineer
ATTN: Dept of Geography & Computer Science
ATTN: DSCPER/MAEN-A

AMMRC, ATTN DRXMR-WE 02172

USA ARRCOM 61299
ATTN: DRCIS-RI-I
ATTN: DRSAR-IS

AMC - Dir., Inst., & Servc
ATTN: DEH (23)

DLA ATTN: DLA-WI 22314

DNA ATTN: NADS 20305

FORSCOM
FORSCOM Engr, ATTN: AFEN-DEH
ATTN: DEH (23)

INSCOM - Ch, Instl. Div
ATTN: Facilities Engineer (3)

HSC
ATTN: HSLO-F 78234
ATTN: Facilities Engineer
Fitzsimons AMC 80240
Walter Reed AMC 20012

MDW, ATTN: DEH (3)

MTMC
ATTN: MTMC-SA 20315
ATTN: Facilities Engineer (3)

NARADCOM, ATTN: DRDNA-F 01760

TARCOM, Fac. Div. 48090

TRADOC
HQ, TRADOC, ATTN: ATEN-DEH
ATTN: DEH (19)

TSARCOM, ATTN: STSAS-F 63120

USACC, ATTN: Facilities Engr (2)

WESTCOM
ATTN: DEH, Ft. Shafter 96858
ATTN: APEN-IM

SHAPE 09055
ATTN: Surv. Section, CCB-OPS
Infrastructure Branch, LANDA

HQ USEUCOM 09128
ATTN: ECJ 4/7-LOE

FORT BELVOIR, VA 22060 (7)
ATTN: Canadian Liaison Office
ATTN: Water Resources Support Ctr
ATTN: Engr Studies Center
ATTN: Engr Topographic Lab.
ATTN: ATZA-DTE-SU
ATTN: ATZA-DTE-EM
ATTN: R&D Command

CRREL, ATTN: Library 03755

WES, ATTN: Library 39180

HQ, XVIII Airborn Corps
and Fort Bragg
ATTN: AFZA-FE-EE 28307

Area Engineer, AEDC-Area Office
Arnold Air Force Station, TN 37389

Chanute AFB, IL 61868
3345 CES/DE, Stop 27

Norton AFB, CA 92409
ATTN: AFRCE-MX/DEE

AFESC, Tyndall AFB, FL 32403

NAVFAC
ATTN: Engineering Command (7)
ATTN: Division Offices (6)
ATTN: Naval Public Works Center (9)
ATTN: Naval Civil Engr Lab. (3)

ATTN: Library, Code L08A NCEL 93043

Defense Technical Info. Center 22314
ATTN: DDA (2)

Engr Societies Library, NY 10017

Natl Guard Bureau Instl. Div 20310

US Govt Print Office 22304
Receiving Sect/Depository Copies (2)

US Army Env. Hygiene Agency
ATTN: HSHB-E 21010

National Bureau of Standards 20899

US Army
- AMCCOM 61299-6000
  - ATTN: AMSMC-ISF-O/Mr. Bob Burchett
- DESCOM 17201-4170
  - ATTN: AMSDS-RM-EFO
- Instl & Svcs Activity 61299-7190
  - ATTN: AMXEN-IU/Mr. Gary Badtram
- Anniston AD 36201-5001
  - ATTN: SDSAN-DAS-FE
- Letterkenny AD 17201-4150
  - ATTN: SDSLE-SFEN
- Lexington-Blue Grass AD 40511-5010
  - ATTN: SDSAN-LAF
- New Cumberland AD 17070-5001
  - ATTN: SDSNC-AF
- Pueblo AD 81001
  - ATTN: SDSTE-PUA-F
- Red River AD 75507-5000
  - ATTN: SDSRR-AE
- Savanna AD 61074
  - ATTN: SDSLE-VA
- Seneca AD 14541
  - ATTN: SDSSE-AD
- Sharpe AD 95331-5310
  - ATTN: SDSSH-AFE-A
- Sierra AD 96113
  - ATTN: SDSSI-FE
- Tobyhanna AD 18466-5078
  - ATTN: SDSTO-AF-E
- Picatinny Arsenal 07801-5000
  - ATTN: SMCAR-ISE-N
- Pine Bluff Arsenal 71602-9500
  - ATTN: SMCPB-FE
- Rock Island Arsenal 61299
  - ATTN: SMCRI-FE
- Watervliet Arsenal 12189
  - ATTN: SMCWV-FEU
- Iowa AAP 52638-5000
  - ATTN: SMCIO-EN
- Kansas AAP 67357-9107
  - ATTN: SMCKA-OR
- Lone Star AAP 75501
  - ATTN: SMCLS-EN
- McAlester AAP 74501
  - ATTN: SMCM[illegible]
- Milan AAP 38[illegible]
  - ATTN: SMC[illegible]
- Cornhusker AAP 68801
  - ATTN: SMCCO-CR
- Newport AAP 47966-0121
  - ATTN: SMCNE-EN
- Badger AAP 53913-5000
  - ATTN: SMCBA-OR
- Sunflower AAP 66018
  - ATTN: SMCSU-OR
- Twin Cities AAP 55112-5000
  - ATTN: SMCTC-EN
- Joliet AAP 60436
  - ATTN: SMCJO-EN
- Ravenna AAP 44266
  - ATTN: SMCRV-CR
- Volunteer AAP 37422
  - ATTN: SMCVO-CA
- Holston AAP 37662
  - ATTN: SMCHO-EN
- Indiana AAP 47111-9667
  - ATTN: SMCIN-OR
- Lake City AAP 64050
  - ATTN: SMCLC-EN
- Longhorn AAP 75670-1059
  - ATTN: SMCLO-OR
- Louisiana AAP 71130-5000
  - ATTN: SMCLA-EN
- Radford AAP 24141-0299
  - ATTN: SMCRA-OR

END
DTIC
6-86